POLLINATION OF RED CLOVER BY TETRALONIA AND MELISSODES.

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The fact that bumblebees are important as pollenizers of red clover has been established by means of numerous experiments dating from the time of Darwin. Their importance in this respect depends, however, upon their numbers at the time when the clover is in bloom. Thus, in second-year clover, in Illinois, bumblebees are highly important as pollenizers of the second crop, for they are abundant in late July, in August and September. They are unimportant as pollenizers of the first crop, however, for in June the only winged bumblebees in existence are the comparatively few queens that have survived the winter, and these spend a large part of their time in the nest, rather than in the field. The June crop is certainly not pollenized to any considerable extent by bumblebees. In fact, it seldom yields much seed as compared with the second crop in the same locality.

Twenty years ago it was taken for granted that there was not enough seed in the June crop to pay for its extraction, but since then more and more farmers have found it profitable, now and then, to cut the June clover for seed instead of hay, and have obtained from one-half a bushel to two bushels of seed (possibly more) per acre in Illinois.

How is the June crop pollenized? From correspondence and from inquiries at Farmers' Institutes I learned that in a few instances the yield of seed had occurred in a region where Italian honey bees were common and had been seen working on the flowers. Now honey bees of this race are undoubtedly important pollenizers of red clover, as Dr. A. D. Hopkins found, and as I have since ascertained. There were, however, some instances in which seed had been obtained from the June crop in places where there were no Italian honey bees; so there still remained some mystery in regard to the means of pollination of the clover field in June.

Mr. W. P. Flint has had *Tetralonia dilecta* Cress. under observation for several years, and has repeatedly found good yields of seed from fields in which this bee had been abundant.

This *prima facie* evidence, brought to my attention by Mr. Flint, led me to make the following observations and experiments with the object of proving whether certain species of *Tetralonia* and *Melissodes* pollenize red clover or not. In this study I had the assistance of Mr. F. Q. Otanes, a graduate student, who was investigating the general subject of insects in relation to the production of clover seed. The species used in our work were kindly determined by Mr. Henry L. Viereck.

1. *Tetralonia dilecta* Cress. = (*T. speciosa* Rob., not Cress.). May 19, 1921, *Tetralonia dilecta* was present, though not abundant, in fields of red clover on the University farm, Urbana, Illinois, and was working busily on the blossoms. The proboscis, thrust into the flower, was visible through the corolla, and evidently extended to the bottom of the corolla tube. Specimens collected from clover heads, taken to the laboratory and examined under a microscope, showed many pollen grains, especially on the mentum and the branched hairs of the mentum, but also on the maxillæ; in fact, pollen grains occurred almost anywhere on the ventral aspect of the mouth parts. These pollen grains were indistinguishable from those of red clover.

May 24, when the bees were abundant, a root cage with parallel glass sides and a cover of wire screen was taken to the clover field; in it was placed a solid row of clover heads in full bloom, and into the cage were introduced specimens of *Tetralonia dilecta*. Some of the bees set to work on the blossoms, and their operations were studied under a hand lens.

It was essential, of course, to determine if seed would be produced by plants upon which *Tetralonia* had worked, and from which all other insects had been excluded. To this end, red clover plants were taken which bore heads with unopened buds; opened heads having been removed from the plants. These plants were transplanted to a large flower pot covered with a cage of wire screen with a mesh of one millimeter, and placed out of doors. In a day or two some of the heads were in bloom and bees were introduced into the cage. May 26, I put thirty individuals of *T. dilecta* into the cage; a few of them were seen to work on the blossoms during the same day; after twenty-four hours, however, all the bees had died. May 31, Mr. Otanes put several more bees into the cage, and some of these also were observed to work on the flowers. The florets

were then allowed to dry, and were examined for seed July 1, by Mr. Otanes and myself. From 789 florets (not counting undeveloped florets that could not have been pollenized) we found 171 seeds. In other words, 21 per cent. of the flowers had been pollenized by *Tetralonia dilecta*.

As a check experiment, red clover plants with heads in bud, but not as yet in bloom, were planted in two flower pots, covered with wire cages and placed out of doors, just as in the preceding experiment, but no bees were put into the cages. After three weeks, when the heads were examined for seed, the first cage contained 357 florets and no seeds; the second, 287 florets and no seeds.

Tetralonia dilecta, abundant until the middle of June, became rare by June 30, but a second species of bee soon appeared on the scene and engaged our interest.

2. *Melissodes bimaculata* LeP. This black species appeared July 5, was common July 7 and 12, but was falling off in numbers July 21. *M. bimaculata*, swifter of flight and more alert than *T. dilecta*, worked actively on clover blossoms in the field. Specimens taken from clover heads showed much pollen, undoubtedly that of red clover, on the mentum, some pollen on hairs adjacent to the mentum, and considerable pollen among the hairs under the eyes.

As before, red clover plants with unopened heads were potted July 12, and covered with a wire cage. July 14, several heads being partly in bloom, I placed seven individuals of *M. bimaculata* in the cage at 2:30 P. M., and one of these was working on the heads ten minutes later. July 15, six of the bees had died. July 16, Mr. Otanes put in eleven more bees; and July 19, five more, some of which were seen to work on the flowers. In all, twenty-three bees had been introduced.

As several bees had apparently been pollenizing florets, we expected to get some seed, at least; but when the dried heads were examined by Mr. Otanes, August 4, the 216 florets that were present yielded only two seeds. Thus the results of this experiment were negative. In a second experiment, however, the results were different.

In this experiment, plants with unopened heads were potted and covered with a cage July 21. July 23, fifteen specimens of *M. bimaculata* were put into the cage; and July 25, sixteen more. Many of these bees were seen working on the flowers.

August 12, the heads were examined for seed, and the 11 heads present, with 293 florets, yielded 90 seeds, or 30 per cent.

These observations and experiments are simple but conclusive. They prove that *Tetralonia dilecta* pollenizes red clover to an important extent in the latter part of May and in June (in central Illinois), and that *Melissodes bimaculata* also is an efficient pollenizer of plants that bloom during July.

The present summary is simply for the purpose of placing these facts on record; a detailed account of further studies being left for a future article.

ARE THERE TWO SPECIES OF THE OYSTER-SHELL SCALE?*

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The Oyster-shell Scale (*Lepidosaphes ulmi*, L.) has been a subject of study on the part of the writer since the spring of 1919. During the summer of that year, observations were made on the biological development of this insect on lilac. In the fall, while making egg counts from various host plants, it was noticed that the scales formed on apple trees seemed to differ in appearance from those on lilac and some of the other ornamental shrubs and trees. It was therefore determined to make a comparative study of the biological development of the insect on apple and lilac the following summer.

Studies of this insect have resulted in the finding of three distinct differences between what may be called the apple and lilac forms:

1. Differences in the appearance of the scales.
2. Differences in biological development.
3. Differences in morphological characters.

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* Contribution from the Entomological Laboratory, Cornell University, Ithaca, N. Y.